Determination of gill-net selectivity for King Fish (*Scomberomorus Commerson,* Lacepede 1800) using Mesh size in Sungailiat, Bangka Belitung Province

Pareng Rengi[1]* (iD)**; Polaris Nasution[2]** (iD)**; Arthur Brown[3]** (iD)**;
Ayu Nita Ervina Tambunan[1]** (iD)

[1]Faculty of Fisheries and Marine Affairs. Universitas Riau, Kampus Bina Widya, Km 12,5, 28293, Kota Pekanbaru, Riau, Indonesia. E-mail: ayu.nita5767@student.unri.ac.id
[2]Fisheries Resources Utilization. Universitas Riau, Kampus Bina Widya, Km 12,5, 28293, Kota Pekanbaru, Riau, Indonesia. E-mail: polarisb2000@yahoo.com
[3]Fish Utilization Department. Universitas Riau, jl.dharma bakti GG bambu, n° 3, 28292, Kota Pekanbaru, Riau, Indonesia. E-mail: arthur_psp@yahoo.co.id
*Corresponding author. E-mail: pareng.rengi@lecturer.unri.ac.id

ABSTRACT

Selectivity is a fishing gear characteristic capable of catching fish of a specific size and species from the existing population distribution. Mesh size is one of the important factors that influence gillnets' selectivity, because different length-classes of fish are caught by them. This report focuses on the selectivity of two mesh sizes of gillnets (8.89 cm and 10.16 cm) on mackerel's catch and constructing a gillnet in Sungailiat waters. Experimental fishing methods and selectivity analysis were used for the fishing gear's more selective preparation, if the largest fishing ratio's value at the fork length (L) is high and the standard deviation value (S) is closer to 1. It is concluded that to be more selective a largest S (L) value of 0.999267194 at fork length (L=54.95 cm), and with a larger value of S (L) 0.997096071 and with (L=66.55 cm) for mesh Sizes 8.89 cm and 10.16 cm, respectively.

Keywords: drift gillnet, fork length, scomberomorus commerson, selectivity, sungailiat.

Determinação da seletividade da rede de emalhar para King Fish (*Scomberomorus Commerson*, Lacepede 1800) usando o tamanho da malha em Sungailiat, província de Bangka Belitung

RESUMO

A seletividade é uma característica das artes de pesca capazes de capturar peixes de determinado tamanho e espécie da distribuição populacional existente. O tamanho da malha é um dos fatores importantes que influenciam a seletividade da rede de emalhar. Devido ao tamanho diferente, eles pegam vários tipos de peixes. Este trabalho centra-se na seletividade de dois tamanhos de malha de emalhar (8,89 e 10,16 cm) na captura de cavala e na construção de uma rede de emalhar nas águas de Sungailiat. O método de pesca experimental e a análise de seletividade foram usados para a preparação mais seletiva das artes de pesca, se o valor da maior razão de pesca para o comprimento do garfo (L) for alto e o valor do desvio padrão (S) for mais

próximo de 1. Conclui-se que para ser mais seletivo dev ter um maior valor S (L) de 0,999267194 no comprimento do garfo (L = 54,95 cm), um maior valor S (L) 0,997096071 e com (L = 66,55 cm) para o tamanho da malha 8,89 cm e 10,16 cm respectivamente.

Palavras-chave: comprimento do grampo, rede de emalhar de deriva, scomberomorus commerson, seletividade, sungailiat.

1. INTRODUCTION

Fisheries play an important role in poverty alleviation, food security, nutrition supply, income, and in general to the community's socio-economic development (Mehanna *et al.,* 2021b). Good fishery management requires proper fishing equipment to catch large adult fish and allow small fish to escape, and at least 50% of individuals would have an opportunity to reproduce (Armstrong *et al.,* 1990). Also, fishing techniques and equipment impact biomass and crops, ecological interactions between species, and productivity and ecosystem functions that can be felt directly or indirectly (Millar and Fryer, 1999; Hall, 1996; Mehanna *et al.,* 2021a; 2021b; Aabeed 2020).

In practice, the selection of fish catches depends on the fish's size rather than age. This is because the fish's size determines the possibility of escaping through the eyes of the net or away from the fishing gear (Mehanna *et al.,* 2021b). Selectivity is the fishing gear's nature that catches fish of a specific size and population distribution species (Lagler, 1978). This property mainly depends on the principle used in the capture and the design parameters of fishing equipment, such as mesh size of nets, materials and thread sizes, hanging ratio, and attractive speed (Tambunan and Agustriani, 2010). In many selectivity studies on fishing, catch rates are much higher for small fishing rods than large fishing rods (Erzini *et al.,* 1996; 1998; 1999; Halliday, 2002). Mehanna *et al.* (2021a) showed that large fishing rods are less efficient at catching small fish and eels but more efficient at catching larger ones. Thus the catch rate, the selectivity of size, and death of fish are influenced by the size and design of the fishing rod (Forster, 1973; Anon, 1983; Skeide *et al.*, 1986; Bjordal and Løkkeborg, 1996)

Although continuously exploited, aquatic organisms' lives still need to pay attention to long-term sustainability, as evidenced by environmentally friendly fishing gear. Drift gillnet is a fishing tool that has environmentally friendly and selective properties. It does not endanger fishermen in taking fish, the catch is suitable for consumption, relatively safe because it only causes minor injuries to the catch, and is safe for marine habitats (Lisna *et al.,* 2018). Selective nature means catching fish at a specific size, and having gone through mature gonads the first time. Gillnet drift selectivity determines the difference in the number of species and biomass captured by various gillnets of various sizes (Adeosun *et al.*, 2011; Ago *et al.*, 2014). Therefore, it is essential to know the nature and selectivity of fishing gear (Anggreini *et al.*, 2017).

One of the fish caught on gillnet drift fishing equipment is mackerel (*Scomberomorus commerson*). This fish is a coastal pelagic species that often migrates in groups (Mundy and Randall, 1996), generally living at a depth between 10 - 70 m by preying on small fish and can reach 2.4 m in length (Froese and Pauly, 2008). The narrow-barred Spanish mackerel is a mackerel spread throughout the Indo-Pacific from the Red Sea to South Africa and Southeast Asia. It is also found to the north in China and Japan, south to Australia, and has migrated through the Suez Canal to the Levant Sea (Golani *et al.*, 2002; Rizkalla and Heneish, 2019).

Sungailiat fishing community in Bangka Belitung Province uses gillnet drift to catch mackerel with mesh size drift gillnet used measuring 8.89 cm and 10.16 cm. According to Rengi (2002), One of the factors that affect the gillnet's selectivity is the net's mesh size. Mesh sizes of different nets will also affect the number of fish caught.

Drift gillnet specifications used by fishermen in Sungailiat waters have differences with

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gillnet drift in other areas. The difference lies in webbing with multifilament choices that are not spun. The available choices result when the net is in the water and enlarges the fish caught in the net. Another difference lies in the type of material webbing made of dark blue nylon multifilament. In contrast, drift gillnet in the waters of Sungailiat is made of transparent multi monofilament nylon with ballast used as part of the net's body. Nets typically weigh more than seawater, resulting in the net sinking below the water's surface.

Based on the Code of Conduct for Responsible Fisheries (CCRF) regarding responsible fishing behavior to maintain fish sustainability, it is necessary to look at the level of selectivity and safety in fishing gear. This study therefore assessed drift gillnet selectivity with mesh sizes of 8.89 cm and 10.16 cm on the catch of mackerel and explored the construction specifications of the gillnet drift fishing equipment used.

2. MATERIALS AND METHODS

Selectivity of Drift Gillnet Mesh Size 8.89 cm and 10.16 cm was evaluated by using the data retrieval method on conducting live experiments on fish caught by gillnet drift fishing in the waters of Sungailiat, Bangka Belitung Province.

2.1. Data Collection
The data used was data on fish's body size that used data analysis and size data in two fishing tools used to construct fishing equipment. Construction measurements range from webbing measurement, rope type measurement, buoy dimension measurement, ballast, and stretcher. Then the measurement results were recorded on the construction measurement table.

This study used two types of gillnet drift fishing tools with different mesh sizes. The second capture size data of mesh size was used as data in the subsequent analysis. Measurements were made to know the hanging ratio of the capture tool by using the formula (Equation 1):

$$E = \frac{L}{Lo} \tag{1}$$

Note:

E = *Hanging ratio*

L = Length of rope ris

Lo = Length of stretched nets

2.2. Data Analysis
The data was analyzed using a fishing gear selectivity test against gillnet drift fishing equipment using data fork length mackerel. Then specified class range and class frequency were determined using the following formula (Walpole, 1995) (Equation 2):

$$K = 1 + 3.3 \, Log \, n \quad I = 1 \, R/K \tag{2}$$

Note:

K = Total class

n = Total data

I = Distance between classes

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R = Max value − min value

The formula used to determine S_L's value and make the selectivity curve was selected based on research Sparre and Venema (1998), as follows (Equation 3).

$$S_L = exp\left\{-\frac{(L-Lm)^2}{2 \ x \ S^2}\right\}$$ (3)

Note:

S_L = Chance of caught fish at a certain length (cm) on a mesh size net

L_m = Optimum length of fish caught on a mesh size net

L = *Fork length of fish caught on a mesh size net*

S = Standard Deviation.

The selectivity curve is obtained from the SL data of each class from the two mesh size nets. According to Dewanti *et al* (2019), the selectivity curve only describes the chances of the fish being caught on the Y-axis and at a specific size on the X-axis. It is also following the research of Manoppo (1999) and Indah and Meilia (2014), which mentions that the capture tool is more selective when the L value is getting bigger, and the value of S is closer to the number 1 (one).

3. RESULTS

3.1. Gillnet Drift Construction
The structure of gillnet drift used by fishing communities in Sungailiat waters is almost the same as the construction of gill nets in general. However, it has characteristics that make its construction slightly different from gill nets in other areas, namely:

1. Yarn material used as webbing is a multi-monofilament thread that is not spun, so when the net is in the water, the thread that is not spun will open. This will increase the chances of catching the fish.

2. Ballast used on gillnet drifts in Sungailiat waters has a different construction than typical gillnet drift ballast. Ballast in the form of a net-connected at the bottom of the body of the net (webbing) of polyvinylidene chloride (PVDC) or so-called advice. Advice is used as ballast because the weight of the type of advice is 1.7 gr / cm3 while the bodyweight of the net (multi monofilament) is 1.14 gr / cm3 (Ardidja, 2010).

Figures 1 and 2 show drift gillnet construction, in sizes 8.89 cm and 10.16 cm.

3.2. Nets (Webbing)
Rectangular-shaped nets with mesh nets (mesh size), namely 3.5 cm and 10.16 cm Drift GillnetSpecification, can be seen in Table 1 below.
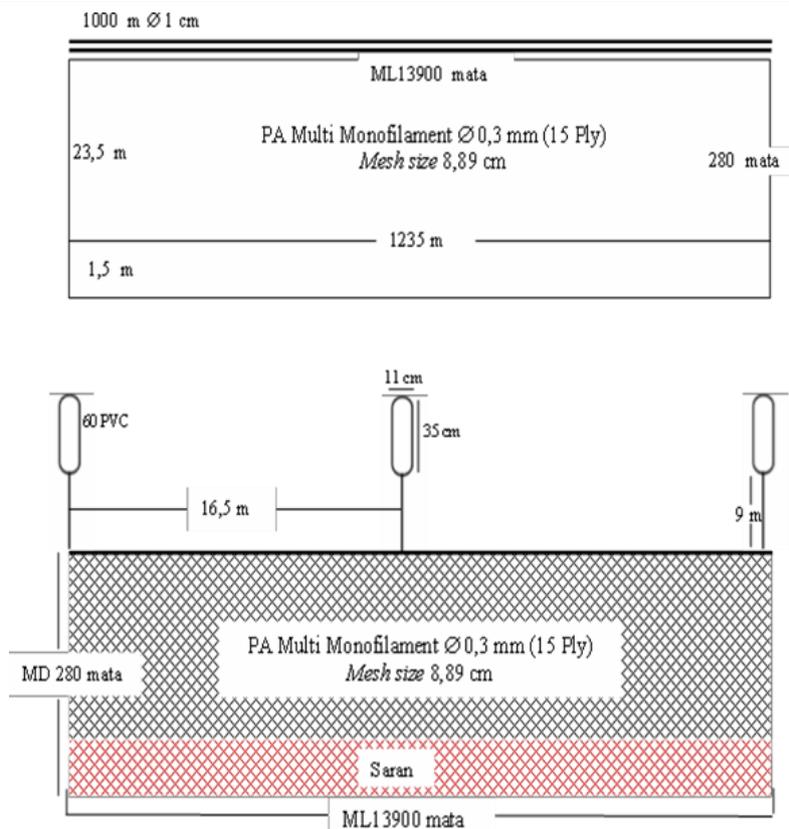
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1000 m Ø 1 cm

ML13900 mata

PA Multi Monofilament Ø 0,3 mm (15 Ply)
Mesh size 8,89 cm

23,5 m

280 mata

1235 m

1,5 m

11 cm

60 PVC

35 cm

16,5 m

9 m

MD 280 mata

PA Multi Monofilament Ø 0,3 mm (15 Ply)
Mesh size 8,89 cm

Saran

ML13900 mata

Figure 1. Gillnet drift construction with mesh size 8.89 cm.

1250 m Ø 1 cm

13900 mata

PA Multi Monofilament Ø 0,3 mm (15 Ply)
Mesh size 10,16 cm

26 m

1412 m

2 m

11 cm

75 PVC

35 cm

17 m

10 m

MD 280 mata

PA Multi Monofilament Ø 0,3 mm (15 Ply)
Mesh size 10,16 cm

Saran

MD 13900 mata

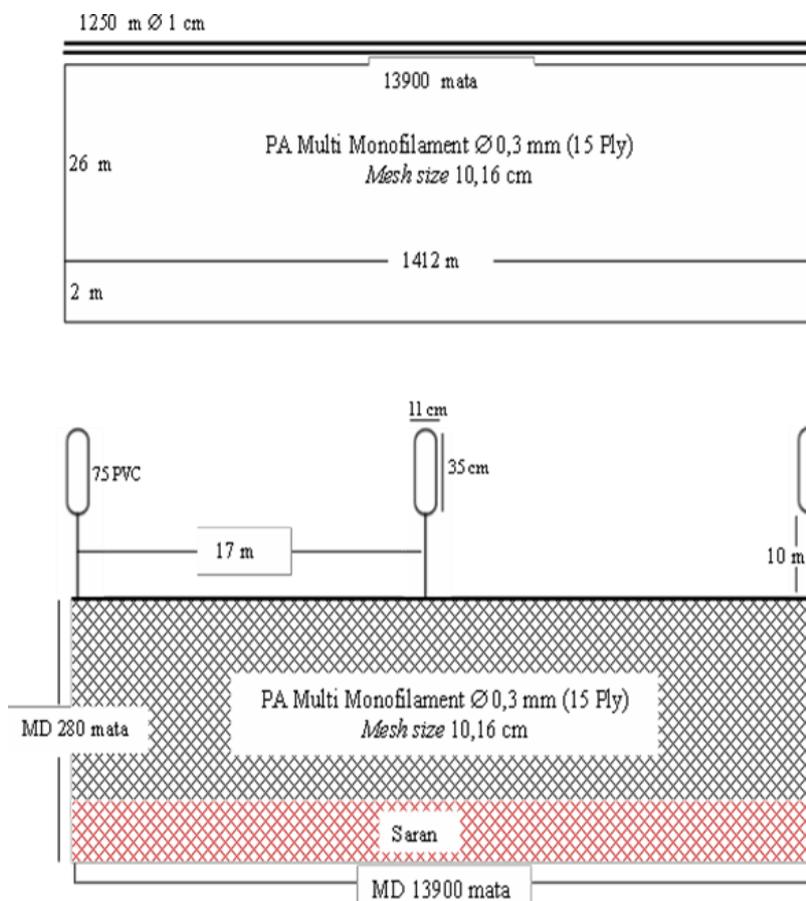**Figure 2.** Gillnet drift construction with mesh size 10.16 cm.

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Table 1. Drift Gillnet Specification.

Net Specifications	Mesh size	
	8,89 cm	**10,16 cm**
Materials	PA Multi Monofilament	PA Multi Monofilament
Node Type	Double English	Double English
Thread diameter (mm)	0.2	0.2
*Mesh length (*mata)	13900	13900
Mesh depth (mata)	280	280
Hanging ratio (%)	61	60
Length of the strained net (m)	1235	1412
Net height (m)	25	28

Based on Table 1, net materials use a type of Polyamide (PA) multi monofilament (15 plies) with a thread diameter of 0.20 mm and not spun, the length of the mesh stretched at mesh size 8.89 cm is 1235 m, and at mesh size 10.16 cm is 1412 m.

3.3. Ris Rope and Life Rope

The upper rope is a rope that connects the net to the buoy rope, while the buoy rope is a place to hang the buoy. The other function of the rope ris is to reduce and withdraw nets and protect from friction with the ship's body during the capture operation. Specifications of ris rope and buoy rope used in fishing gear can be seen in Table 2 below.

Table 2. Ris Rope and Buoy Rope Specifications.

Ris Rope and Life Rope	Mesh Size	
	8.89 cm	**10.16 cm**
The length of the top ris rope (m)	1000	1250
Length of buoy strap (m)	9	10
Ris strap diameter (mm)	10	10
Buoy strap diameter (mm)	10	10
Shortcut direction	S	S
Materials	PE	PE

3.4. Buoy

Buoyancy serves to provide buoy on the net. Oval-shaped white PVC material (Polyvinyl Chloride) is used for buoyancy while buoys serve as a sign of the position of nets in the water. Buoy marks used are round and made of black PVC (Polyvinyl Chloride). Specifications of buoys and buoy markings can be seen in Table 3 below.

Table 3. Drift gillnet Buoy Specifications.

Buoy Specifications	Mesh Size	
	8.89 cm	**10.16**
Materials	PVC	PVC
Forms	Oval	Oval
Diameter (mm)	110	110
Lengths (cm)	35	35
Quantity	60	75
Distance between buoys (m)	16,5	27
Material buoy sign	PVC	PVC

3.5. Gillnet Drift Operating Techniques

Fishers perform the preparatory stage before going to sea, namely filling the necessary supplies such as fuel, clean water, ice, and foodstuffs. Preparation begins with checking the ship and fishing equipment, and then the ship goes to the fishing ground. The fishing ground is the water where fishers fish. The waters are believed to hold the maximum numbers of fish. The way fishers determine fishing grounds is based on fishers' experience while at sea. The fishing ground is in the Sungailiat waters of the South China Sea and can be reached by ship at a speed range of 35-50 miles per hour navigating for 3 to 4 hours.

Upon arrival at the fishing ground, the fishers began by lowering the net into the water with a position against the water current's direction to counter the movement direction of the swimming fish. The setting process was done around 4-5 pm, as this was believed to be the best time based upon previous experience. Two fishermen lowered the net, and the setting process began when the sign buoy dropped. Then the net along with the rope was slowly lowered into the water until the net stretched perfectly. After the net was stretched, the next process was to tie the diving rope to the ship so that the net did not drift into the ship. After the setting process finished, the nets were left for 6-7 hours in the water. The last process was hauling, which takes about 2-3 hours when the hauling is done by three people, where one pulls a rope and buoys onto the boat, and another person pulls the net while taking the caught fish. The caught fish were put in a box called a "fiber" that had been filled with ice to keep the fish fresh until the ship arrived at port. Then the ship returned home to the fishing base with the catch.

3.6. Total Catches

The total fish caught during the study on gillnet drift fishing equipment was 369 fish with a total catch weight of 630.5 kg. The fish caught consisted of pelagic fish of different types. The most caught fish was mackerel.

In the drift gillnet with mesh size, 8.89 cm caught 213 fish with a total weight of 309.1 kg, while the mesh size of 10.16 cm caught 156 fish with a total weight of 321.4 kg. The catch is shown in Figures 3 and 4 below.
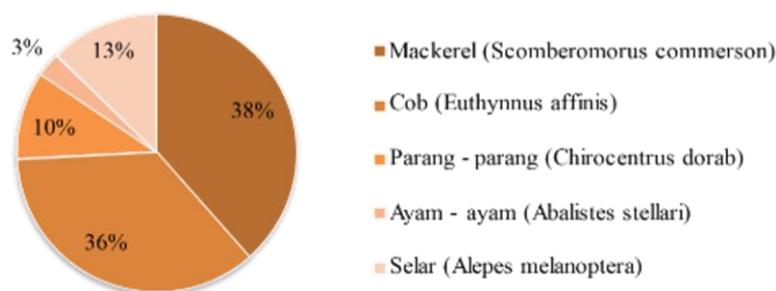

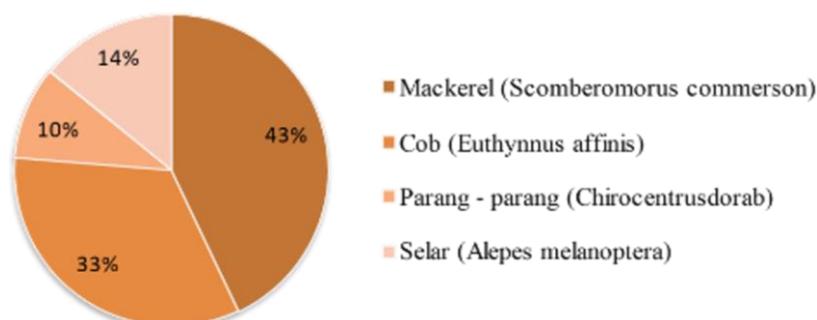**Figure 3.** Fish caught on drift gillnet with a mesh size of 8.89 cm.

Figure 4. Fish caught on drift gillnet with a mesh size of 10.16 cm.

Based on Figure 3 and 4, known fish caught on drift gillnet with mesh size 8.89 cm, namely Mackerel (*Scomberomorus commerson*) 38% (Lacepede, 1800), Cob/Kawakawa (*Euthynnus affinis*) 36% (Cantor, 1849), Parang-parang/Dorab wolf-herring (*Chirocentrus dorab*) 10% (Forsskål, 1775), Ayam-ayam/Starry Triggerfish (*Abalistes stellari*) 3% (Bloch & Schneider, 1801), and Selar/Blackfin Scad (*Alepes melanoptera*) 13% (Swainson, 1839).

In contrast, the fish caught on drift gillnet with mesh 10.16 cm, namely Mackerel (*Scomberomorus commerson*) 43% (Lacepede, 1800), Cob/Kawakawa (*Euthynnus affinis*) 33% (Cantor, 1849), and Parang-parang/Dorab wolf-herring (*Chirocentrus dorab*) 10% (Forsskål, 1775), and Selar/Blackfin Scad (*Alepes melanoptera*) 13% (Swainson, 1839).

3.7. Mackerel Body Measurement

The measurement of mackerel's body (*Scomberomorus commerson*) is the most common catch on gillnet drift-fishing equipment. Measurement includes total length, standard length, fork length, body width, and fish-body girth. The body size range of mackerel caught with mesh sizes of 8.89 cm and 10.16 cm is shown in Table 4.

Table 4. The body-size range of mackerel (*Scomberomorus commerson*).

N°	Mesh Size (cm)	Total Length	Fork Length	Body Width	Body Girth	Fish Weight (kg)
1	8.89	35 – 90	26 – 82	8 – 12	19 – 27	0,8 – 3
2	10.16	49 – 115	42.5 – 107	10 – 14	22 – 30	1 – 5.3

Based on Table 4, the difference in the size of the mesh eye (mesh size) shows the difference in catches that include the difference in the size of the total length, fork length, body width, body girth, and weight of mackerel (*Scomberomorus commerson*). The catch with a mesh size of 10.16 cm catches a larger fish compared to a mesh size of 8.89 cm. Following the opinion of Yahya and Sulaiman (2008), the larger mesh size of the net obtains a catch with a larger fish length size and vice versa. According to Takwin (2005), pelagic fish properties such as mackerel are also causing caught fish to have several size groups. However, it has not explained the degree of selectivity of the fish's body size difference. Therefore, it is necessary to take further measurements and analysis.

Long relationships and the circumference of the fish's body by conducting a regression analysis on mackerel (*Scomberomorus commerson*) shows how much influence on the circumference of the body of the mackerel. The results of the analysis show in the following image.

Regression analysis between the fish's length and the fish's body circumference, as shown in Figure 5, obtained the equation on the fishing tool with a mesh size of 8.89 cm is y = 0.1085x + 16.508. It shows that as each mackerel length increases by 1 cm, the average circumference of its body increases by 0.1085 cm. The coefficient determination (R) of $R^2 = 0.5286$ indicates that the fish-length factor affects the circumference of fish by 52.86%, while other factors influence the remaining 47.14%. While the correlation value (r) is 0.73, this value (r) close to 1 means that the length and circumference of the body can be a real relationship. The mesh size 10.16 cm obtained the equation y = 0.1463x + 15.702. This shows that as each mackerel length increases by 1 cm, the average circumference of the body increases by 0.1463 cm. Coefficient determination (R) of $R^2 = 0.7123$ indicates that the fish length factor affects fish's circumference by 71.23%, while other factors influence the remaining 28.77%. While the correlation value (r) is 0.84, this value (r) close to 1 means that the length and circumference of the body can be real or affect relationships.
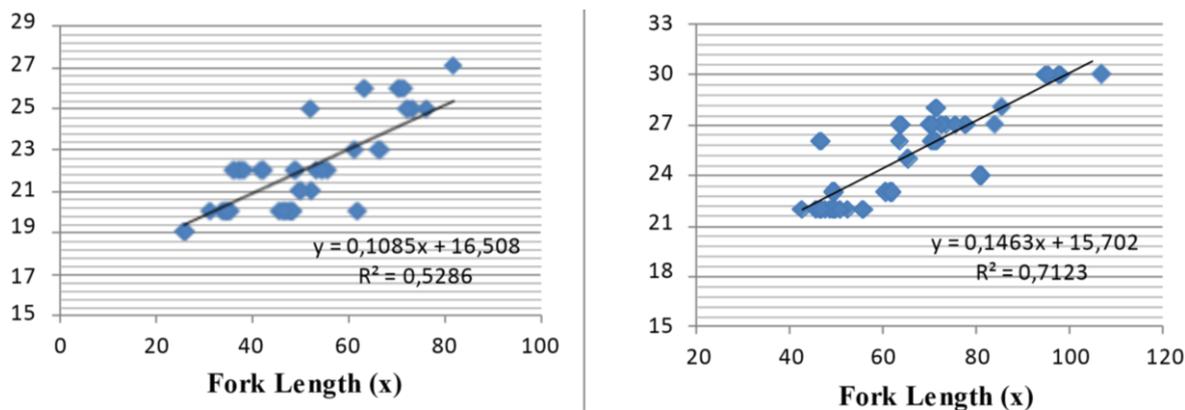
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Figure 5. Fork Length and Body Girth relationship graph of mackerel caught on the difference of mesh size 8.89 cm and 10.16 cm.

3.8. Selectivity Analysis

The calculation fork length of the most-caught fish is mackerel (*Scomberomorus commerson*), judging by the mackerel class's long spread. The fish-body size data used in the data analysis is fork length and then determined each class's range. The fork-length frequency distribution is shown in Table 5.

Table 5. Fork-Length Frequency Distribution.

Class Range	Mesh Size	
	8.89 cm	10.16 cm
26 - 37.5	20	0
37.6 - 49.1	28	12
49.2 - 60.7	17	13
60.8 - 72.3	12	25
72.4 - 83.9	5	10
84 - 95.5	0	4
95.6 - 107.1	0	3

From the table above, we estimated the value a = -0.4942986 and the value b = 0.00821684 by regressing between the number of fish caught with the median value of the fish-fork length. Then we obtained the value of SF = 16.04180643, the value of S2 = 976.1542937, and the l m values on both mesh sizes: 56.1463225 cm and 64.16722571 cm.

Then we calculated the value of S(L) using a predefined formula. The value that was obtained was used to determine the curve of the selectivity ratio. The S(L) values that were obtained are as follows (Equations 4 and 5):

Drift Gillnet mesh size 8.89 cm $\qquad$ $S(La) = exp\left\{-\dfrac{(L-56,146)^2}{2\,(976,154)}\right\}$ $\qquad$ (4)

Drift Gillnet mesh size 10.16 cm $\qquad$ $S(La) = exp\left\{-\dfrac{(L-64,167)^2}{2\,(976,154)}\right\}$ $\qquad$ (5)

From the equations of the function obtained, a selectivity curve of mackerel fish (*Scomberomorus commerson*) was formed. The selectivity curve shows whether the fishing gear is selected or not by calculating the probability or chance value of catching fish with each fishing gear (Dewanti *et al.*, 2019). The curve can be seen in Figures 6 and 7 below.
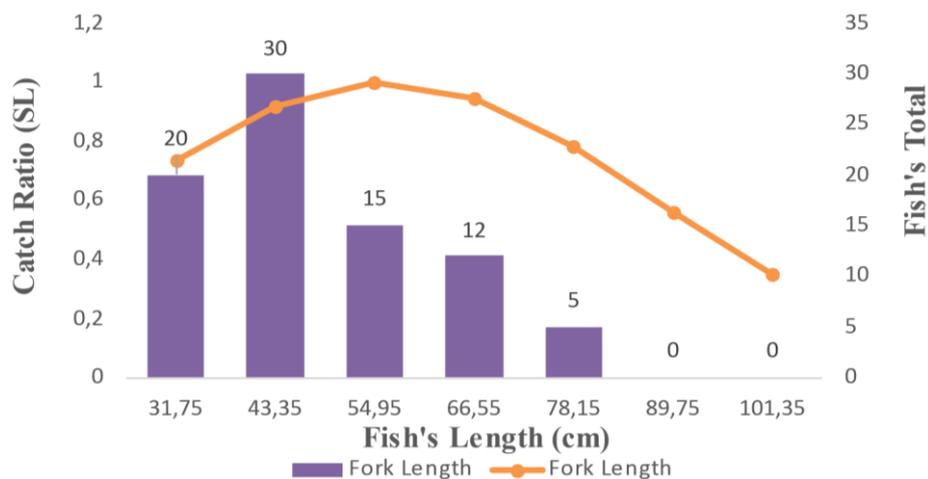
Figure 6. Selectivity chart of mackerel gillnet drift catch (*Scomberomorus sp.*) at a mesh size of 8.89 cm.
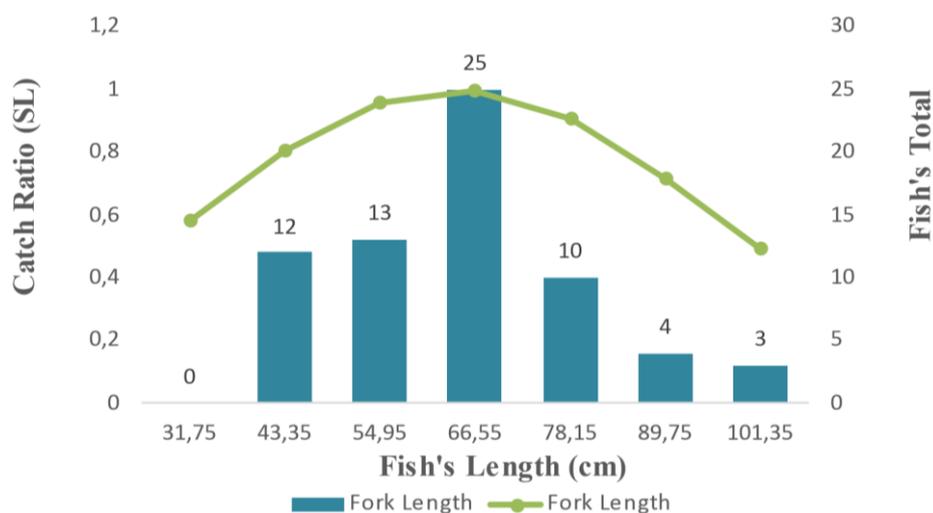

Figure 7. Selectivity chart of mackerel gillnet drift catch (*Scomberomorus sp.*) at a mesh size of 10.16 cm.

In Figure 6, the largest catch ratio value for S (L) is 0.999267194 at fork length (L) = 54.95 cm, totaling 15 fish. Whereas in Figure 7, the largest S (L) value is 0.997096071 at fork length = 66.55 cm, totaling 25 fish. Based on this, the drift gillnet with a mesh size of 8.89 cm is more selective in catching mackerel than drift gillnet with a mesh size of 10.16 cm. These results are following the research of Manoppo (1999) and Indah and Meilia (2014), which states that the greater the fork length (L) and the closer the standard deviation (S) value to 1.00 will make the selectivity value of fishing gear more selective.

4. CONCLUSION

The construction of drift gillnet in Sungailiat waters is different from drift gillnet generally. The net body is made of polyamide (PA) multi monofilament exact color, and the mesh sizes used are 8.89 cm and 10.16 cm. The weight used in drift gillnet is part of the net's body, located under the net's body, and is commonly known as the net's foot with generally green or brown tendencies. The net legs are made of Polyvinylidene Chloride (PVDC), commonly called a "nest" with a diameter of 0.5 mm and about 1.5 to 2 m.

Based on the selectivity curve, drift gillnet with a mesh size of 8. 89 cm is more selective

in catching mackerel with the largest S (L), namely 0.999267194 and fork length = 54.95 cm, totaling 15 fish compared to drift gillnet with mesh size 10.16 cm with the largest S (L), specifically 0.997096071 and fork length = 66.55 cm, amounting to 25 fish.

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